

Responses from review panel and audience

Larry Germann, Lefthand Design Corporation

What is the frequency uncertainty of the 0.5 Hz sunshield mode and the 0.7 Hz secondary mirror torsion mode? If they get within 10% of each other, they may couple to increase the secondary mirror motion.

There is a similar concern with the 4.5 Hz sunshield modes, which may interact with the 4.1 and 4.9 Hz secondary modes. If the energy of the 4.5 Hz sunshield modes is low enough, there may be no problem.

If there is no simple answer to these concerns, the sunshield modes should be represented in the model used for optical distortion, i.e. the sunshield model should be augmented to include the elements that cause these modes.

The modes should be toleranced to their worst-case proximity to each other to determine worst-case coupling.

Jim Targrove, ORA

The baseline Be model relies on cold figuring out the impact of CTE inhomogeneity during the initial cooldown. We heard this morning that the spatial frequency for these effects on SIRTf is 5-6 cycles across the mirror. While the reduced inhomogeneity of spherical powder Be helps, the much larger petal size in NGST means that the surface deformations could be microns. This is too thick to polish out (in a reasonable time), so the SIRTf legacy for correction is much less direct. It is therefore worth looking at the degree of figuring needed since it is so key to the baseline design.

I was free associating on your kind request for additional error sources for the NGST phasing, and came up with this one. Pierre mentioned that he (and Kim Mehalick) looked at the wide-angle telescope scatter, and found it to be benign because of the lack of a bright source in the field. I asked him previously if he was sensitive to near angle scatter from a star due to surface microroughness and contamination, which broadens the PSF. The answer was that this system does not have a near angle requirement, so no need to worry. It occurs to me, however, that you are the near angle requirement, as this effect gives you a spatially varying noise source. The mirrors are currently being carried at 20 Angstroms rms, and the contamination is probably undefined. Probably worth a look.

Lisa Hardaway, University of Colorado

Elasticity and Inelasticity, Clarence Zener

Zener shows damping as a function of absolute temperature for everything else being equal. You may want to check into this since going from warm temperature to operating temperature could cause some heartache. This doesn't help with whether .001 is right or not but may help w/ qualitative factors.

Gary Wilkerson, Micro Craft, Inc.

Although IMOS is a tremendous breakthrough for the direct prediction of optical performance degradation due to any error source in the presence of the entire spacecraft's related parameters, have IMOS' subroutines been employed long enough to be reasonably assured they have been debugged?

Optical and structural materials CTE, conductivity, and emissivity data gathering as a function of cryogenic temperature (40K-200K) needs to be energized.

Robert Bamford, JPL (retired)

Simple isolator design is single degree of freedom. Before using results at high attenuation, model system as at least a two degree of freedom system including the isolator spring mass.

Evaluate error due to induced secondary moments at, and of, actuator flexures.

Evaluate effect of omitted high frequency sunshield modes in system model. A possible procedure is attached.

Assume:

- Sunshield simple model matches low frequency cantilever mode effective mass and merges all higher mode effective mass at sunshield interface.
- There is a critical free-free mode f_c of the overall system including the simple sunshield model.

Procedure:

- Estimate maximum effective m_c mass that a higher mode of the sunshield could have at f_c .
- Remodel with the simple sunshield model modified to include a cantilever mode at f_c with mass m_c .
- Rerun the overall system to estimate effect of omitted sunshield modes.
- Evaluation of f_c is not addressed here. The added mode is a dynamic absorber and will reduce motion at f_c but the reaction can excite other modes.

Stuart Shaklan, JPL

Optical Diffraction Modeling: Is it necessary to include diffraction from primary mirror edges around secondary spiders? Probably not, but a quick MACOS run can verify this.

Modeling: Detector non-linearity may be an issue. Probably don't want to go above 75% of full well (just a guess). Ask Trauger for some HST calibration data.

Lawrence “Robbie” Robertson, USAF Research Lab

Structures

- Need more detail
 - Show one petal model of flexures, bipod, etc.
 - Hinge and latch modeling: UltraLITE program discovered deployable boom frequency modeled as 8 Hz turned out to be 2 Hz on H/W. Problem traced to mechanism interface. Maybe look at this.
- Model reduction
 - Spatial reduction should be done by examining transfer function differences.
 - Modal reduction should be done using modal participation, Hankel model reduction, etc. (lots of good methods).

Thermal

- More detail seems to be in the works, but need another review to show true “proof of concept” between thermal systems (cryocooler, conductivity at edges of sunshield layers, etc.).

Bill Hayden, GSFC

Non-ideal segment actuator flexures and kinematics need to be added.

Develop plans to implement modal frequency sensitivity analysis for both centroid and WFE; shape input for expected disturbances.

Need to model thermal performance of sunshade as a function of small-scale non-parallel layer geometry and random shorts.

Need to add gamma-alumina to dynamics model.

Need realism in OTA/SC thermal conductance and cable harness and α/ϵ .

What-if studies using IMOS thermal solver to optimize thermal design, i.e. petal shapes, backing structure insulation, etc.

FSM range is decreased (effectively) by the telescope magnification, therefore its usable range could be easily saturated due to ACS drift, thus an off-load of this bias error to the ACS is needed and should be modeled.

Keep the modeling goals in mind. Favor sensitivity studies rather than detailed modeling of a particular yardstick implementation; develop key system-level engineering requirements; provide a report (or presentation) on the technology roadmap/requirements that you are providing.

Look at major transient events – thermal snap, large and small slews, etc.

Mirror material anisotropy – sensitivity to placement and number of actuators.

Gary Mosier, GSFC

Need to do a better job of communication as a team.

Need to do a better job of model documentation and configuration control.

Vibration isolation model is inadequate. Current results are too optimistic. Need a more robust ACS design that is less sensitive to changes in modal frequencies and damping.

Should develop a graphical user interface for the ACS design tools, linear analysis tool and simulation tool. Need a more time-efficient simulation. Need to modularize the parameter initialization script.

Model order reduction with optimal performance metrics should be done using transfer function methods rather than simulations. Must include effects of all controllers and a more representative input spectrum.

Need a faster eigensolver for IMOS, or a return to NASTRAN for dynamics analysis of the point design.

Need a simpler dynamics model for more effective parametric sensitivity studies. Need to do more sensitivity studies and feed the results through Systems IPT to the Technology IPT.

Pierre Bely, STScI

Structural modeling

1. Mirror support bipods should be modelled with their flexures
2. We need to have a scheme for supporting the mirror blanks during polishing (and derive if there is any need for special supports or blank structure reinforcements)
3. We should include a dependence of the Young modulus (E) on temperature.
4. We should make sure that the E values for all materials (mirror and structure) that we use are valid at low temperature.
5. When we model structural elements as c-bar, this assumes that the cross section is rigid. To ensure that this is the case, we should include diaphragms in those members (and include these diaphragms in the mass estimate - both for overall mass budget and dynamics).
6. We need to include deployment "position errors" in the structural model (they are included in the wavefront model).
7. We should not arbitrarily limit our list of modal frequencies to the first 100 modes. Instead, we should go much beyond (1000Hz), and keep those modes which affect the optics.
8. We need to include the sunshield "film dynamics" in our model. "Flapping" will not be elastic. We may need multibody analysis.
9. We have to demonstrate that the simplifications done in the sunshield (only 4 bars, which results in throwing away modes) has no influence on the telescope model results. For example we should make a series of special runs with a higher fidelity sunshield model to verify that.
10. To analyze the U of A mirror model, we will need 2 models:

- overall model with less actuators for dynamics and thermal analyses
- a detailed model for a single petal, where each actuator is represented and there are several mirror facesheet node between each actuator

11. We need to do a sensitivity analysis where we would independantly vary the natural frequency of the main modes to search for worst cases (coupling -- overlapping of modes).

12. Lisa Hardaway indicated that structural damping is proportional to the absolute temperature (i.e. it would be very low at our operating temperature). She will send a reference on that.

13. Bertrand Koehler from ESO indicated that at room temperature, but at very low amplitudes (100 nm range), structural damping (for steel?) was in the 0.6 to 0.75%.

14. Robbie Robertson warned us of the effect of structural interfaces (joints, attachments etc..) on the modal frequencies. This pushes for including detailed models of these interfaces.

Disturbances

15. For a general audience, we need to do a better job at proving that our design does avoid exciting the secondary mirror (0.1 micron tolerance), provided that we have quiet reaction wheels. This is only a presentation issue. We may need a special viewgraph addressing this specific problem.

16. Propellant slosh is best prevented by using a pressurized diaphragm

17. Larry Germann warned us of "unmodeled disturbances" at the microradian level (thermal snapos, hunting of control subsystems, propellant slosh)

Optical modeling

18. Need to include CTE anisotropy in the mirror and other sensitive structural elements

19. For our info, the SIRTf mirror CTE anistropy result in 4 or 5 cycles of figure error over its 90 cm diameter, The amplitude is about 2 waves at 0.5 microns

20. We need to include polishing printthrough and other effects in the mirror model

21. We should include error due to "imperfect calibration" in the wavefront sensing measurement fed to the active optics system

22. We should check if it is true that the secondary mirror supporting "knife-edges" diffraction can be considered as "far field". Right now we assume they are in the entrance pupil.

23. We should use an actual psf in the guider model (we had planned to)

Thermal modeling

24. We need to include realistic values for the conduction in the isolation truss (structure, wires, pipes)

25. We need to include thermal conductivity between the layers of the sunshield to account for:

- shorts (due to contact between layers)
- conduction through the tubular structure supporting the layers

26. We need to study the pros and cons of thermal conduction between the mirror petals. Conduction will reduce the overall gradient over the full aperture (good to reduce the hot/cold slew effects) but will increase the gradient in each petal.

Analysis tools

27. IMOS is clearly a powerful tool during phase A studies. But will it still be practical when models get more detailed (during phase C/D)? Is it simply a computer power problem that can be fixed by more powerful computer or are there more fundamental limitations? Two possible solutions:

- use IMOS only for overall performance studies, using simplified models, and rely on traditional analysis software (NASTRAN, codeV etc..) for the detailed analyses
- abandon IMOS and run directly NASTRAN, SINDA, CodeV (or MACOS?) in a MATLAB environment

General

28. According to our analyses, the most important factors are:

- reaction wheel noise
- structural damping

It is therefore essential that we pinpoint realistic values for these two factors. First by literature search, and then by testing if needed.

29. The 40 db attenuation that we assume for the RWA isolation may be more difficult than we think in practice. We need to go beyond the paper study on that, and perform actual lab tests.

30. We should investigate the possibility of using active noise cancellation techniques for reducing reaction wheel noise instead of passive isolation.

31. We need to make more runs to fully explore the trade space (type of wavefront sensing, RWA disturbance level, guide star brightness, etc) and build up a data base of options with their corresponding specifications. Note that with integrated modeling, "Error budgets" are an obsolete

concept during phases A and B, since everything is to remain negotiable until procurement time. But exploring the trade space would allow defining practical ranges for each of the main parameters, and give insight on the feasibility of various approaches.

32. We should also use the model for optimizing the current design (using IMOS optimization)

33. Finally, we should attempt using the model for performing parametric cost studies (the ultimate benefit of integrated modeling).

Modeling Peer Review Attendees - 1/23/98 @ JPL

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